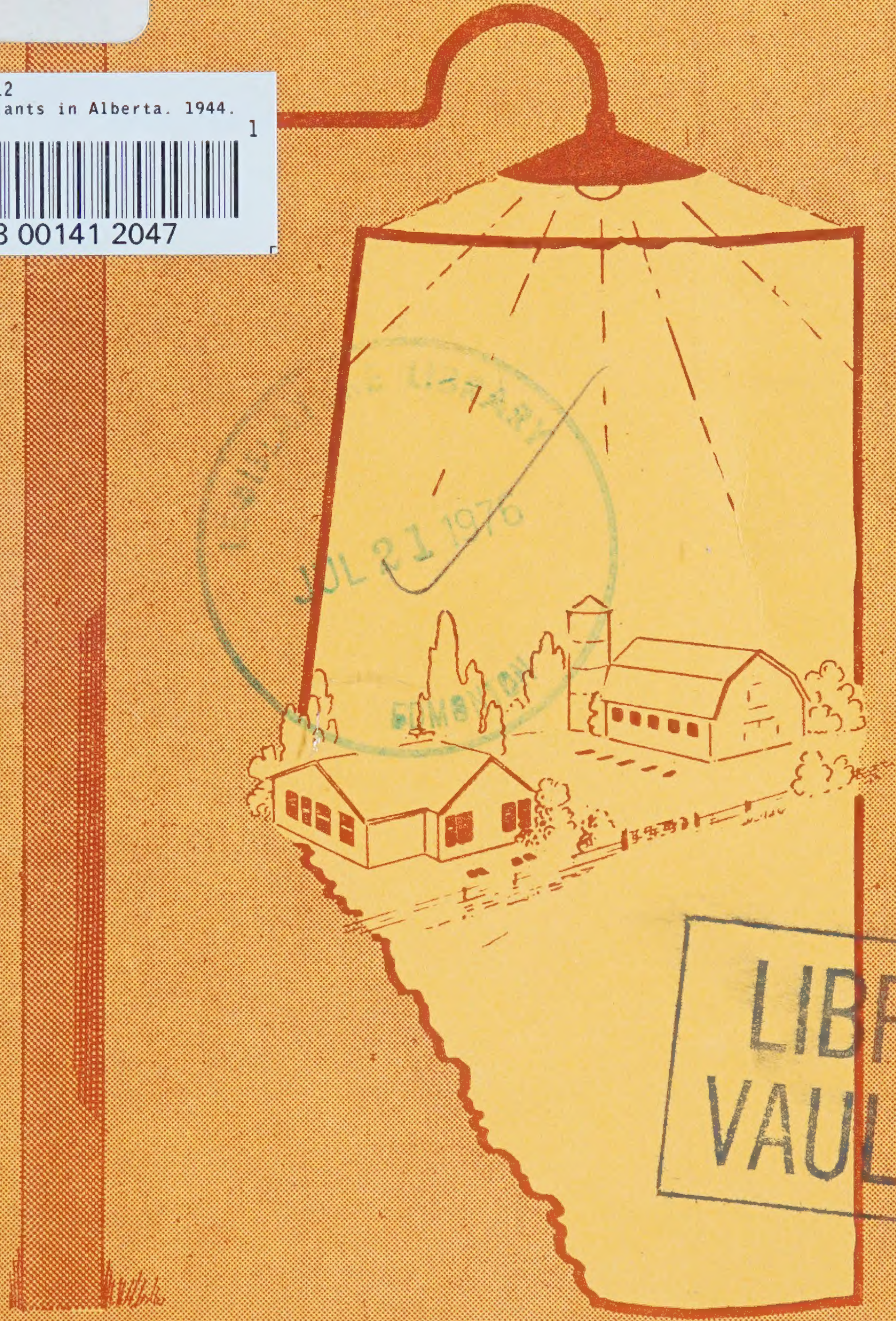
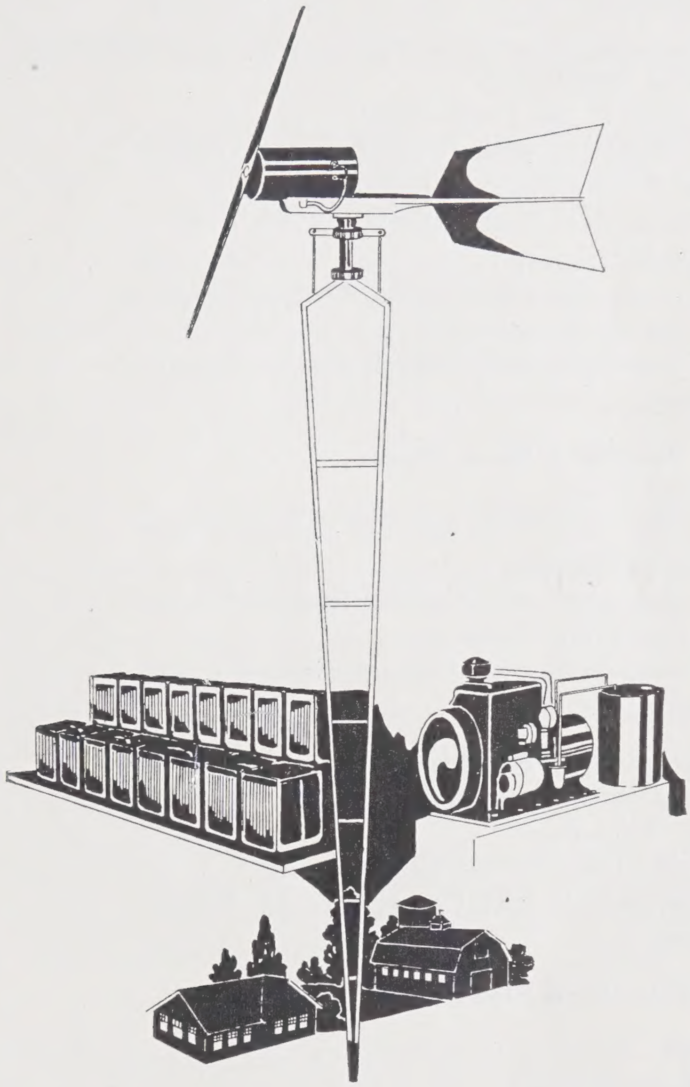
FARM ELECTRIC PLANTS IN ALBERTA



ALBERTA POWER COMMISSION

Farm Electric Plants in Alberta



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FARM ELECTRIC PLANTS IN ALBERTA

Farm Electric Plants in Alberta

A survey of individual farm electric plants in Alberta was carried out during the summer of 1944. Visits were made to farms in a number of districts extending from north of Edmonton to the Calgary area. Records covering the operations of plants were obtained from 157 farms. These records included information on the type and size of plant, capital investment, operating expenses, uses and appliances installed, and the farmers' experience with the plant. Unless otherwise indicated the data in this report are based on the records of the survey.

The main body of the report deals with the 32-volt plant. However, a separate section dealing with the 6-volt plant is included.

Throughout the report comparisons are made between the costs of operating individual farm electric plants, and the costs of providing central station power over farm distribution lines. The costs of central station power are taken from a report on "Rural Electrification in Alberta" which was completed prior to the survey of farm plants.[1]

I. Types of Plant in Use on Alberta Farms

THE NUMBER OF INDIVIDUAL FARM PLANTS IN ALBERTA.—The exact number of farm electric plants in Alberta, and their location, are difficult to determine. The Census of 1941 reported 5.5 per cent of the farms in Alberta as having electricity. This would represent approximately 5,500 farms. Information from other sources indicates that, in 1941, there were about 500 farms receiving central station power. Consequently, the number of farms with individual plants must have been about 5,000. It is known that between 1941 and 1944 a considerable number of plants were sold to farmers in Alberta. The number now on farms in this Province is probably over 6,000, and may be nearer 7,000[2].

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[1]"Rural Electrification in Alberta", Research Council of Alberta, Report No. 36 1944. (Not Available for Distribution.)

[2]Through the cooperation of the largest distributor of electric plants an effort was made to study the location of plants in the Province. This study was discontinued when it became apparent that no complete or closely accurate description of location was possible. Many makes of plant have been sold in Alberta; and some of them are not now being manufactured or distributed. Further, plants occasionally change hands, and their location is no longer known. From observations made during the survey it seems evident that wind plants have a wider distribution in the southern part of the Province.

THE TYPES OF PLANTS.—Four types of electric plants are found on Alberta farms. These are the gasoline-driven plant; the wind-driven plant; the combination plant; and the diesel plant.

Gasoline plants have been in use in Alberta for a long period of time. In the survey, some farmers reported the purchase of this type of plant as early as 1910. Quite a number were installed on farms during the last war, especially in 1917 and 1918. Some of these early plants have ceased to give service, whereas others have had periodic overhauls and are still in operation.

Most wind-driven plants have been installed since 1936. Table 1 shows the year of purchase of the 83 wind plants covered in the survey. Eighty per cent of these plants were purchased since 1938.

Table 1.—Year of Purchase of Wind-Driven Plants.

Year of Purchase	Number of Plants	Three-Year Totals	Three-Year Percentages
1936 or before	2		%
1937	3		
1938	12	17	20
1939	12		
1940	18		
1941	11	41	50
1942	11		
1943	9		
1944[1]	5	25	30
Total	83	83	100

[1]Up to and including September 1944.

Increased sales of wind-driven plants are associated, in part, with a tendency to install a combination plant consisting of a wind-tower with an auxiliary engine. Between 20 per cent and 25 per cent of the wind plants in the survey were being used in conjunction with engines. Other farmers interviewed expressed the opinion that the combined plant was best. There appears to be a significant trend in the direction of the combined plant.

Diesel plants are found on a few farms where the power requirements are large, and the load may be too heavy for the other types of plant. One farmer, with a 2,000 watt, 110-volt diesel plant operates the ordinary electrical appliances and, in addition, a pressure pump, stoker, refrigerator, grain cleaner, and a large elevator. Operators of diesel plants were well-satisfied with the service and low operating costs of their engines. This suggests that the diesel plant might best meet the situation on some large farms.

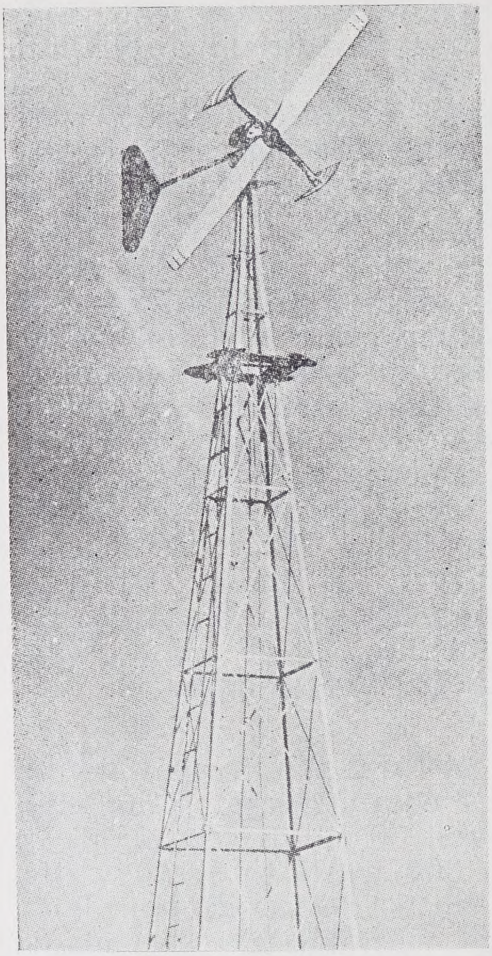
THE MAKES OF PLANTS AND BATTERIES.—The plant most commonly found on Alberta farms is the Delco. Other engine plants include Fairbanks-Morse, Dominion, Genco, Johnson, and Macleod; and the Lister diesel. Certain makes of plant are no longer manufactured, and operators of these plants have difficulty in securing parts and service. Trade names commonly found on wind plants include: Wincharger, Addison, Viking, Ruralite, Esco, Parris Dunn, Air Electric, Winpower, and Air Charger. Of these, the Wincharger appears to be most common. Makes of batteries recorded in the survey include: Globelite, Delco Light, Wincharger, Esco, Smith, and Alberta Battery Company.

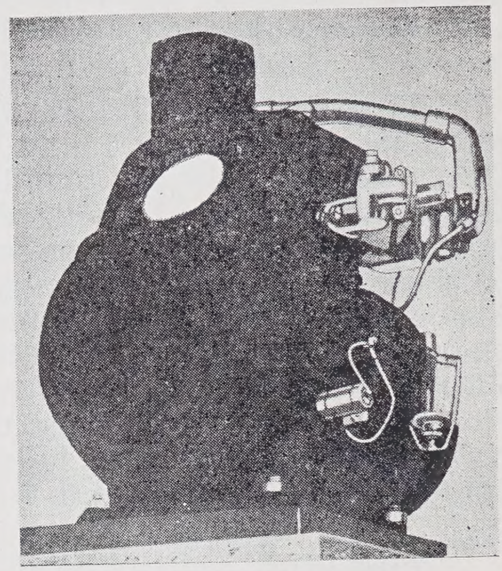
THE SIZE OF PLANTS.—Most farm plants are 32-volt. Some 6-volt plants are found, more frequently among the wind plants. Diesel plants may be 110-volt. Wind-driven plants in the survey ranged from less than 600 watts to 1,250 watts, the most common size being 1,000 watts. Engine-driven plants had a somewhat wider range of size, with 800-850 watt plants found most frequently (Table 2).

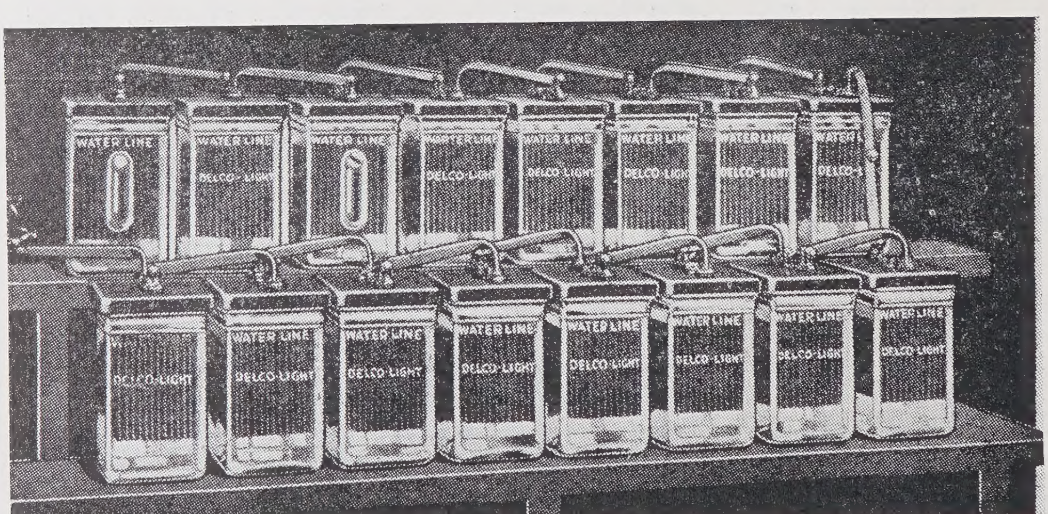
Table 2.—Size of Wind-Driven and Engine-Driven Plants.

Wind-Driven Plants			Engine-Driven Plants		
Watts	Volts	No. of Plants	Watts	Volts	No. of Plants
Various	6	13	150-500	6	5
600	32	3	500-750	32	13
650	32	17	800-850	32	64
800	32	4	900-950	32	3
850	32	10	1,000	32	17
1,000	32	23	1,250	32	5
1,200	32	5	1,500	32	7
1,250	32	8			

Among the combination plants various combinations were found, the most common being a large wind plant with an 850 watt engine (Table 3).







Lighting Plant Equipment Found on some Alberta Farms

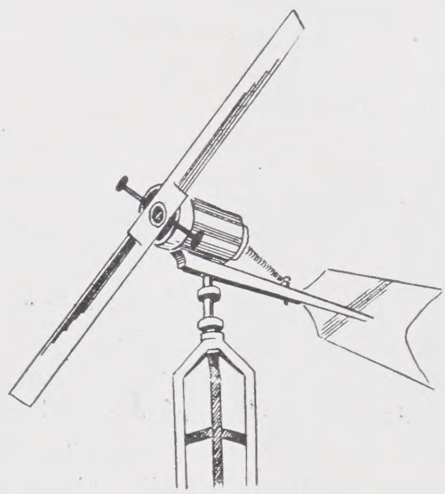
Table 3.—Size of Combination Plants[1].

Classified According to Size of Wind Plant — Watts	No. of Plants	Classified According to Size of Engine Plant — Watts	No. of Plants
Less than 850	9	Less than 850	10
850-1,000	6	850-1,000	19
1,000 and over	20	1,000 and over	6

[1]One combination plant consisted of a small 6-volt wind plant with a 150 watt, 6-volt engine plant.

In the majority of cases, farmers appeared to be satisfied with the plants they had. However, a number expressed the view that their plant should be larger, and that 1,000 watts was a minimum size. Under wartime conditions farmers are prepared to take the size of plant available, although this may not always be the size they would choose to have. Furthermore, recent increases in farm incomes have placed farmers in a better position to make the greater investment in the larger plant. In any case there appears to be a trend in the direction of the larger size plant. The desire for greater capacity is further evidenced by the trend toward combination plants; and by reports from distributors who state that manufacturers in the United States intend to feature the larger units as their "first run plants".

TREND IS TO—



—LARGER PLANTS

Experience in the United States seems to provide confirmation of the trend toward larger plants. Information on wind plants in Iowa indicates sizes ranging up to 5,000 watts, with 2,500 watts the most common size. Iowa farmers, considering purchasing new plants are reported as expressing a preference for the 2,500 watt size (Table 4).

Table 4.—Size of Wind-Driven Plants in Iowa[1].

Generator Size	Number Reporting this Size	Number Report Preference for New Plant
Watts		
120	1	—
650	11	4
750	1	—
800	—	1
1,000	11	9
1,250	1	4
1,500	13	12
1,800	2	1
2,000	5	3
2,400	1	—
2,500	31	25
3,000	1	3
3,750	1	1
5,000	1	2
No statement	13	28

[1]Summary of Replies to Second Questionnaire Sent to Iowa Farm Users of Wind Electric Plants; A. E. 339; p. 6, Table XIV, and p. 7, Table XV; Iowa State College of Agriculture.

Plants on Alberta farms generally have batteries consisting of 16, 2-volt glass jar cells. In the survey, it was found that occasionally 5 car batteries and one 2-volt cell were substituted for the standard battery equipment. While no information was obtained on the ampere-hour rating of the batteries, some variation can reasonably be assumed.

SUMMARY.—1. There are three main types of farm electric plant, namely, the wind-driven plant, the gasoline driven plant, and the combination plant. A few diesel plants are found on farms with unusually large power requirements.

2. Gasoline plants have been in use longer, and are more common than wind plants. The latter have come into more general use in the last few years. The combination plant is also a development of the last few years.

3. Among the wind-driven plants the 1,000 watt is the size most commonly found. A high proportion of the engine-driven plants are 800 to 850 watts.

4. There appears to be a trend toward the larger size of plant. This is evident from the opinions of farmers and distributors, and is confirmed by experience in the United States. The trend toward the combination plant is further evidence of a desire for greater capacity.

II. CAPITAL INVESTMENT IN FARM PLANTS, WIRING OF BUILDINGS, AND ELECTRICAL APPLIANCES

INVESTMENT IN THE FARM PLANT.—The total capital required to install a farm plant depends upon the type and size of plant. The following table is based on the information obtained in the survey (Table 5).

Table. 5.—Capital Investment in Farm Plants.

Type of Plant	Size	Investment[1]
	Watts	$
Wind Plant and Batteries	600- 850	400
Wind Plant and Batteries	1,000-1,250	575
Engine Plant and Batteries	850	400
Engine Plant and Batteries	1,000	450
Combination Plant and Batteries	Various	700

[1]The average values have been expressed in round figures in this table.

The plant investment shown in Table 5 is derived from the records of the actual expenditures of farmers on plants, including batteries. The averages indicated include different makes of plants purchased over a period of years during which there have been some changes in price. In the case of engine plants, both new and rebuilt engines are included; and the averages recorded may be lower than the prices at which farmers could purchase new equipment.

For small plants, wind- and engine-driven, the average investment was approximately $400. The large wind plant generally cost somewhat more than the comparable size of engine plant. The combination plant, including as it does both a wind-tower and engine involves a higher capital investment. The average investment in combination plants was $700.

Comparison with Central Station Power.—Capital investment in farm plants ranging from $400 to $700 may be compared with the construction costs involved in providing central station power to farms. There are two difficulties in making this comparison. First, the service provided may differ considerably between different plants, and between plants and farm lines.[1] Second, while the cost of a plant of a given size may be the same for all farms, the capital cost **per farm** of line construction depends on the density of farms, or, more accurately, on the number of farm connections per mile of line.

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[1]For a discussion of service, see p. 19.

In an earlier study of farm electrification it was estimated that, if 30,000 farms within 12 miles of the existing transmission lines in Alberta were to be served by 6,900 volt farm distribution lines, the average capital cost per farm would be about $600. In this connection the number of customers per mile was estimated to be 1.35. In the report on this study, it was pointed out that, if a smaller number of farms (perhaps 10,000) were served, in selected areas of greater density of farms such that the number of customers per mile would average 1.75, capital costs might be reduced to $500 per farm. In comparing these estimates with the cost of farm plants, it is important to keep in mind the assumptions on which the estimates are based. It is clear that, only under certain conditions, could any particular farm be served with central station power at a capital cost of $500 or $600.

COST OF WIRING FARM BUILDINGS.—The cost of wiring farm buildings varies, depending upon the size of plant, the number and size of buildings wired, the distance between them, and the number of outlets provided. Other factors which affect wiring costs include the type of current, appliances, and wire used.

The amount of wiring with the individual farm plant is generally moderate. There are a number of reasons for this. First, the capacity of many plants is limited. Second, line loss of energy is an important factor with 32-volt D.C. power. Third, to reduce line loss heavier wiring may be used; but heavier copper wire is more expensive. These considerations are particularly important where a small plant is installed. With large single or combination plants the expenditure on wiring may be substantial.

Information obtained from the survey of farm plants indicated the average cost of wiring to be $139. The expenditure per farm ranged from $10 to $500. The Iowa study referred to above showed an average expenditure of $124, with costs ranging from $10 to $400 per farm[1].

Comparison with Central Station Power.—The cost of wiring buildings for central station power is likely to be greater than for the individual farm plant. More outlets will probably be provided, and more appliances installed. The Manitoba Electrification Enquiry Commission estimated wiring costs at $150 per farm[2]. Information on costs of wiring farm buildings in the Swalwell area suggests an average cost of $230 per farm[3].

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[1]Iowa State College of Agriculture, op. cit., p. 8.

[2]Report of Manitoba Electrification Enquiry Commission, Table 30, p. 127.

[3]Information obtained through courtesy of Canadian Utilities Ltd. The Swalwell area is one of three test farm distribution systems constructed in Alberta in 1944.

In making a comparison between the cost of wiring for farm plants and central station power, it must be remembered that for various reasons wiring for the individual plant is generally not as extensive; furthermore, most of the cost figures for farm plants were based on pre-war prices.

COST OF APPLIANCES.—Reference is made later to appliances found on farms with individual plants[1]. From this information it is possible to arrive at a rough estimate of the investment in appliances. Estimates for the various types and sizes of plants are given in Table 6. These estimates are given in round figures which indicate that they are merely approximations, intended to represent the average investment. On some farms the investment is frequently substantially lower; while other farms with more equipment have larger investment in appliances.

Table 6.—Estimated Investment in Electrical Appliances.

Type of Plant	Size of Plant	Estimated Investment in Appliances, per Farm
	Watts	$
Wind plant	600- 850	150
Wind plant	1,000-1,250	200
Engine Plant	850	150
Engine Plant	1,000	200
Combination Plan	Various	250

Comparison with Central Station Power.—Information on the appliances on farms served with central station power is difficult to secure. The earlier report on "Rural Electrification in Alberta" suggested that the initial cost of installations might average $300 per farm. Experience with the test areas constructed during 1944 suggests that this estimate may be low[2]. For purposes of comparison with individual farm plants, it may be assumed that the average investment in appliances on farms served by distribution lines would be not less than $375.

TOTAL CAPITAL INVESTMENT.—The total capital investment involved in securing electrical energy from the individual farm plant includes the investment in plant and batteries, wiring of buildings, and appliances. The amount involved might vary from $650 for the small wind or engine plant to $1,100 for the combination plant (Table 7).

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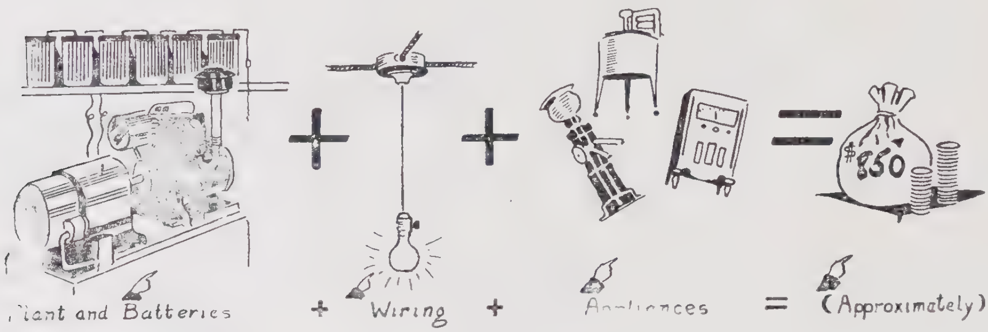
[1]See pp. 20-25.

[2]Information secured through the courtesy of Canadian Utilities Ltd. and Calgary Power Co.

Table 7.—Total Capital Investment.

Type of Plant	Size of Plant	Investment in Plant	Investment in Wiring	Investment in Appliances	Total Investment
	Watts	$	$	$	$
Wind plant and batteries	600- 850	400	100	150	650
Wind plant and batteries	1,000-1,250	575	150	200	925
Engine plant and batteries	850	400	100	150	650
Engine plant and batteries	1,000	450	150	200	800
Comb. plant and batteries	Various	700	150	250	1,100



CAPITAL INVESTMENT

Comparison with Central Station Power.—It has already been emphasized that the cost of line construction per farm depends on the number of connections per mile of line. Under the conditions described above the line cost per farm would be $500-$600. Adding to this wiring costs and appliances averaging respectively $225 and $375, the total investment per farm would be $1,100-$1,200. It appears probable, therefore, that under any general scheme of farm electrification with central station power the investment per farm would be higher than with the individual farm plant. The higher investment cost is, in part, a direct reflection of larger consumption and greater service from the power line. In both cases, the investment cost estimated is for average conditions, and is lower than would be expected if full use were made of the available capacity. With fuller use, investment in wiring and appliances would be greater.

SUMMARY.—1. The investment in the farm plant ranges from $400 to $700.

2. Wiring of farm buildings, with the 32-volt D.C. plant, is often limited. The average cost of wiring may range from $100 to $150 depending on the size of plant.

3. Investment in appliances is difficult to estimate, but may average $150 to $250, depending on the size of plant.

4. Total investment in plant, wiring and appliances appears to range from $650 for small plants to $1,100 for combination plants.

5. Comparison with central station power is difficult because the capital cost of farm lines **per farm** depends upon the number of connections per mile of line. Under certain conditions it has been estimated that line construction costs per farm would average $600. Wiring costs and investment in appliances would probably be higher on farms served with central station power, and total investment for such farms is estimated at $1,100-$1,200. It appears probable that, under any general scheme of farm electrification with central station power, the investment per farm would be higher than with the individual farm plant. This higher investment is, in part, a reflection of larger consumption and greater service from the power line.

III. COSTS OF OPERATING FARM PLANTS

OVERHEAD COSTS.—Overhead costs include interest and depreciation.

Availability of funds at low rates of interest would make an appreciable difference to costs. In computing interest charges a rate of 3 per cent has been used.

Average Life of Batteries is About 8 Years

Farmers rarely accumulate depreciation reserves in order to have a fund available to replace farm equipment. Consequently in computing depreciation on farm plants no allowance has been made for a sinking fund. Based on evidence from the survey the average life was assumed to be 20 years for the plant and 8 years for the batteries[1]. As most of the wind plants had been purchased since January 1939, the estimates of the probable life of these plants were based on expectations rather than actual experience[2].

Estimated overhead costs for farm plants are given in Table 8.

Table 8.—Overhead Costs for Farm Plants.

Type of Plant	Size of Plant	Interest* (annual)	Depreciation* (annual)	Overhead Costs Annual	Overhead Costs Monthly
	Watts	$	$	$	$
Wind plant and batteries	600- 850	11.88	33.15	45.03	3.75
Wind plant and batteries	1,000-1,250	17.43	47.88	65.31	5.44
Engine plant and batteries	850	11.73	34.95	46.68	3.89
Engine plant and batteries	1,000	13.35	38.30	51.65	4.30
Combination plants	Various	20.67	50.95	71.62	5.97

*Interest and depreciation have been calculated on the average investment to the nearest dollar rather than on the rounded values given in Table 5.

Comparison with Central Station Power.—In the earlier report on farm electrification it was assumed that capital for the construction of farm distribution lines might be secured at 3 per cent interest. The annual interest charge, with construction costs estimated at $600 per farm, would be $18.

[1]The life of reconditioned Engine Plants was assumed to be 15 years.

[2]The Manitoba Electrification Enquiry Commission used 20 years life in estimating the depreciation on wind plants. "A Farm Electrification Programme", p. 200.

The average life of farm distribution lines was estimated at 25 years. It was assumed that provision for line replacement would be made through a sinking fund, and that a levy of 2.75 per cent per annum would provide for recovery of the capital cost over the life of the lines. The sinking fund levy would then amount to $16.50 per farm per year, or $1.38 per farm per month.

Using the procedure outlined the total overhead charges, in connection with the provision of central station power, might be $34.50 per farm per year, or $2.88 per farm per month[1]. It will be observed that these costs are signficantly lower than the corresponding costs for farm plants; the differences being due to the longer average life assumed for farm lines, and the provision for depreciation by a sinking fund levy[2].

OPERATING EXPENSES.—The main expenses incurred in operating farm plants are for repairs, and for fuel and oil[3] (Table 9).

Table 9.—Operating Expenses of Farm Plants.

Type of Plant	Size of Plant	Annual Operating Expenses	Monthly Operating Expenses
	Watts	$	$
Wind plant	600- 850	2.72	0.23
Wind plant	1,000-1,250	8.00	0.67
Engine plant	850	37.62	3.13
Engine plant	1,000	37.10	3.09
Combination plant	Various	21.75	1.81

Repair expenses for the wind plant are normally low. Where a larger expenditure occurs it is usually the result of an accident caused, for example, by high wind or lighting. The engine plant has more mechanical parts subject to wear, and consequently periodic overhauls are necessary. The information from the survey suggests that repairs for wind-driven plants may vary from $1 to $6 a year, and for engine

[1]Calculating interest and depreciation in the same way, but assuming that construction costs averaged $500 per farm, annual overhead costs would be $28.75, or $2.40 monthly.

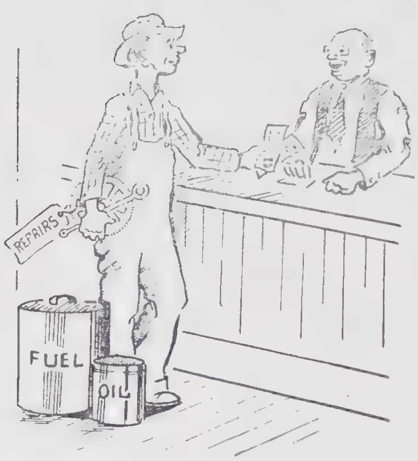
[2]While the annual and monthly costs for central station power are lower than for individual farm plants, partly because of the different method of providing for depreciation, the difference in procedure appears justified by the realities of the situation in either case. It might well be argued that a higher rate of interest, perhaps 5 per cent, should be charged in the case of farm plants. This adjustment would more than balance the increase in overhead charges on farm lines if depreciation were calculated at 4 per cent.

[3]For detailed statements of operating expenses, see Appendix A.

and combination plants from $5 to $11. These amounts represent the average repair bill for different groups of plants. In individual cases the expenditure on repairs was considerably higher[1].

Fuel expenditures appear to vary from $20 to $25 a year for motor plants, and from $5 to $10 for combination plants.

Total operating expenses of wind plants are low because of relatively small expenditures on repairs, no fuel, and negligible expense for lubricating oil. The moderate operating expenses in connection with the combination plants result from the practice of using the wind plant as the main source of energy, and the engine plant as an auxiliary. This reduces both the repair bill and the expenditure on fuel. Relatively high repair and fuel bills account for the higher operating expenses in the case of engine plants.



Monthly Operating Costs—Fuel, Oil and Repairs

Comparison with Central Station Power.—Operating expenses in connection with farm distribution lines include salaries and travelling expenses of men engaged in patrolling and servicing lines; materials for repairs; maintenance of meters and transformers; meter reading, billing and collections; promotional expenses; central office administrative expenses. These have been estimated to total $23.88 a year, or $1.99 per month. For comparison with the operating expenses of farm plants, it is necessary to add the cost of energy, which has been estimated at 1.65 cents per kwhr. The total cost of energy depends on the annual or monthly consumption. Assuming constant operating expenses, exclusive of energy, total operating and energy expenses at different levels of consumption would be as follows:

Monthly consumption Kwhr	Operating and energy expenses $
20	2.32
30	2.49
40	2.65
50	2.82
60	2.98

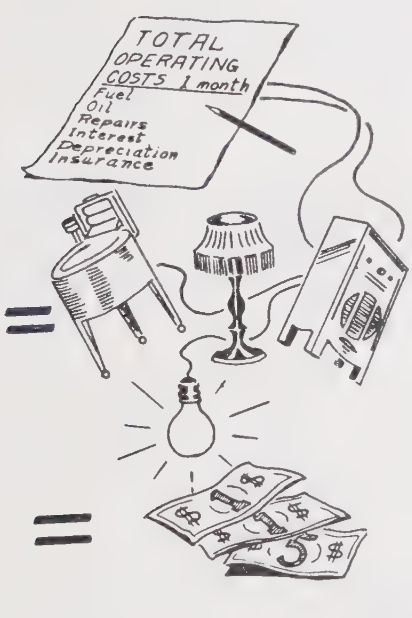
[1]The estimates from the Alberta survey may be compared with the repair expenses of $5.19 reported for Iowa plants. Iowa State College, op. cit. p. 8.

Operating expenses of wind plants are small, while those for combination plants are less than $2 per month. With consumption ranging from 20 to 60 kwhr, farm line expenses are estimated between $2 and $3 per month[1]. Operating expenses are over $3 per month in the case of engine plants.

TOTAL OPERATING COSTS. — Overhead costs and operating expenses are combined in Table 10.

Table 10.—Total Operating Costs of Farm Plants.

Type of plant	Size of Plant	Total Operating Costs Annual	Monthly
	Watts	$	$
Wind plant	600- 850	47.75	3.98
Wind plant	1,000-1,250	73.31	6.11
Engine plant	850	84.30	7.02
Engine plant	1,000	88.75	7.39
Combination plant	Various	93.37	7.78



Total Operating Costs

As already pointed out, the costs presented in the table are those for representative sizes of wind and engine plants. The range in costs would be wider if both larger and smaller plants are included. However, the costs shown indicate the typical costs in connection with the operation of farm plants. Total costs range from $4 to $7 a month for wind plants; from $6 to $8 a month for engine plants; and from $7 to $9 a month for combinations plants[2]. In comparing these estimates of operating costs, it must be borne in mind that the services provided are not necessarily comparable[3].

Comparison with Central Station Power.—Under the conditions already described, that is, electrification of 30,000 farms

[1]Estimates of the consumption of energy with farm plants are given on p. 27.

[2]The Manitoba Electrification Enquiry Commission estimated the annual costs of a large wind plant at $76.96.

[3]The services provided by different types and sizes of plant are discussed later in this report. See p. 19.

with 1.35 connections per mile of line and tap-off, total costs per month have been estimated at $5.20 with a consumption of 20 kwhr per month. Assuming that other costs are constant, regardless of the consumption the total cost per month would increase by 16.5 cents with each increase in consumption of 10 kwhr, reaching $6.52 at a monthly consumption of 100 kwhr.

The energy consumed from individual farm plants generally falls between 20 kwhr and 60 kwhr per month. In the case of farm distribution lines the total costs at 60 kwhr per month would be about $6.00. This is approximately the same as the cost of operating a large wind plant; and is lower than the cost of operating a motor or combination plant.

Two important elements of real cost have not been taken into account in these calculations and comparisons. One is the cost of the farmer's own time and effort. Another is the cost of operating the various small gasoline engines (such as the pump engine) in use on the majority of farms, in addition to the lighting plant. While these factors cannot be closely estimated, their inclusion would add least to the cost of central station power and most to the operation of the engine plant.

SUMMARY.—1. Overhead costs of farm plants, computing interest at 3 per cent and depreciation at 20 years on the plant and 8 years on the battery, range from $45 a year for small wind and engine plants to $72 a year for combination plants.

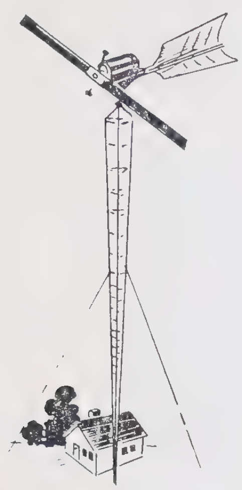
2. Expenses of operating wind plants are small, averaging $8 a year for large plants. With higher repair bills, and fuel expenses, total operating expenses for engine plants average about $37 a year. The comparable figure for combination plants is about $22.

3. Total operating costs range from $4 to $7 a month for wind plants; from $6 to $8 a month for engine plants; and from $7 to $9 a month for combination plants. In comparing these estimates of costs, it must be borne in mind that the services provided are not necessarily comparable.

4. Estimates of total monthly costs for energy supplied over farm distribution lines range from $5.20 with a consumption of 20 kwhr per month to $6.52 with a consumption of 100 kwhr. This level of costs compares closely with the costs of operating a large wind plant; and is lower than the cost of operating an engine or a combination plant. If a charge for the farmer's time and effort were included this would favour central station power and the wind plant in comparison with the engine plant.

IV. SERVICE AND ENERGY PROVIDED BY FARM PLANTS

SERVICE AND CONVENIENCE.—It is only in the last few years that wind plants have become widely distributed in Alberta; and consequently experience with this type of plant is relatively limited. However, like most machines, the wind plant appears to have both advantages and disadvantages.



It is Necessary to Get the Charger Well Into the Air

To a certain extent, the plant is affected by conditions over which the farmer has no control, including the frequency and velocity of the wind. But this disadvantage can be minimized by the exercise of good judgment in the selection of a site and in the height of tower installed. Very few plants have towers of 60 feet or more; the average being from 40 to 45 feet. In all cases it is necessary to get the charger well into the air, so that it will not be affected by eddy currents around the house or by calms created by the proximity of shelter belts. When good judgment has not been exercised in the selection of a site or the height of tower, farmers often complain of lack of wind.

In Alberta wind conditions are least favourable during the winter months, and, between mid-December and mid-February there are frequently periods of two to three weeks when the wind is not strong enough to drive the generator. These periods tend to coincide with the peak load of consumption; and with their occurrence the farmer may be without energy for some time. This can be avoided, if at all, only by the installation of an extra heavy set of batteries and careful conservation and use of energy.

Ice forming on the propellor may cause it to vibrate and wabble. This frosting can be partly controlled by the application of paint or varnish to the propellor. At least four of the farmers visited had had their plants blown down; but this is generally the fault of improper installation of the footing and of the guy wires. Two or three farmers had their plants struck by lightning, and the generators burned out. Occasionally the brakes fail to operate in a high wind, causing damage to the generator.

Against these disadvantages the wind plant has some substantial advantages. In the first place, it is convenient to operate and requires little attention. Secondly, excepting central station power, it is probably the safest means of light-

A Wind Generator on an Alberta Farm.

ing on the farm as it requires no fuel oil. Thirdly, the operating expenses are small.

On the whole farmers appear well pleased with their wind plants. Comments from farmers indicate that the most satisfactory results are obtained when a large generator (1,000 watts or more) is used in conjunction with a heavy set of batteries. Often farmers are not satisfied with the operation of a 650 watt generator and a light set of batteries. The generator does not charge the batteries fast enough at lower wind velocities; and, in addition, the batteries will not carry the load for long if the wind fails.

As might be expected the principal use of the plant is for lighting, although other appliances are operated (Table 11).

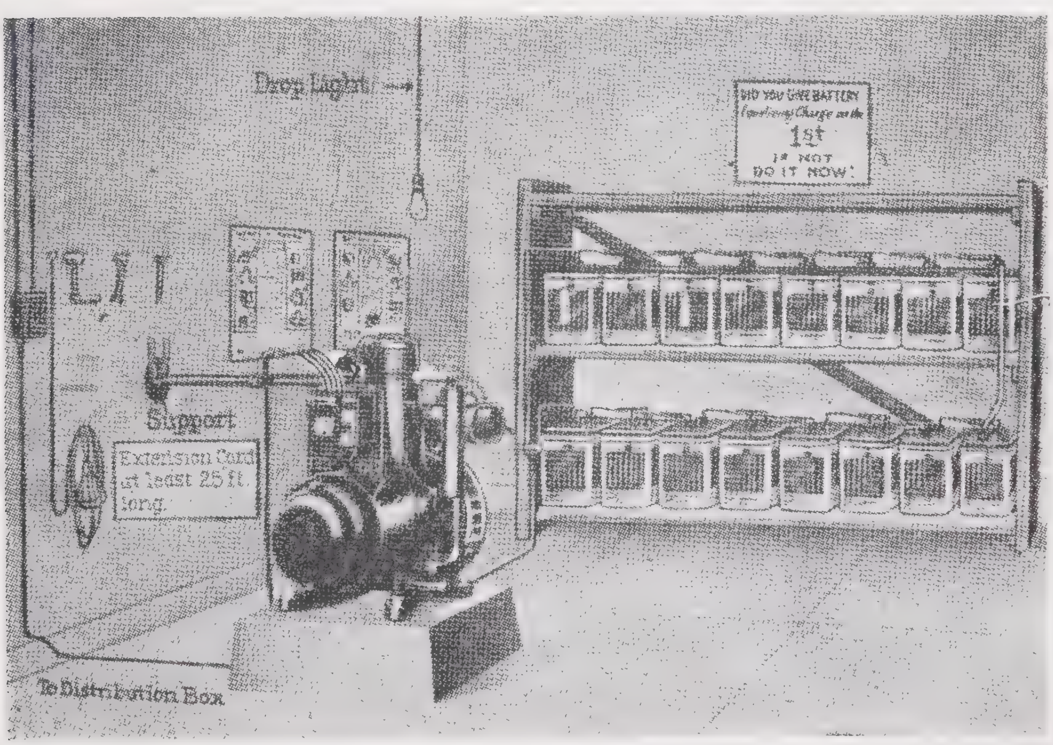
Table 11.—Appliances in Use on Farms with Wind Plants

Size of Plant	Lights per Farm	Proportion of Farms with Radio	Proportion of Farms with Washing Machine
Watts	No.	%	%
600-850	19	42	63
1,000	24	44	94

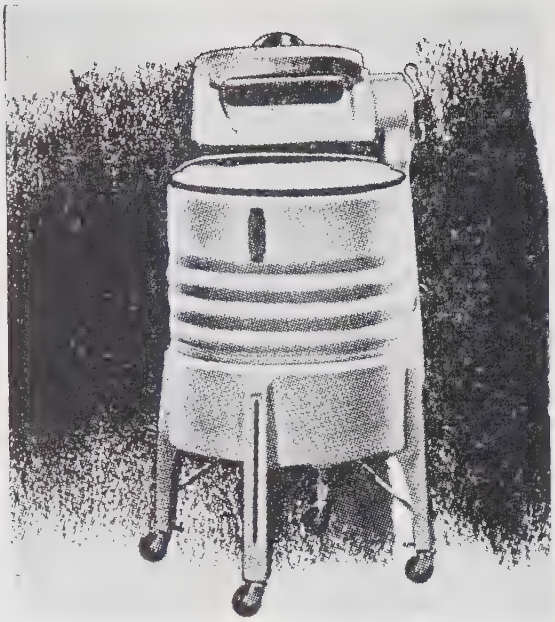
In addition to the radio and washing machine, 40 other appliances were reported on the 35 farms. These appliances included the iron, vacuum cleaner, electric pump, sewing machine, and cream separator.

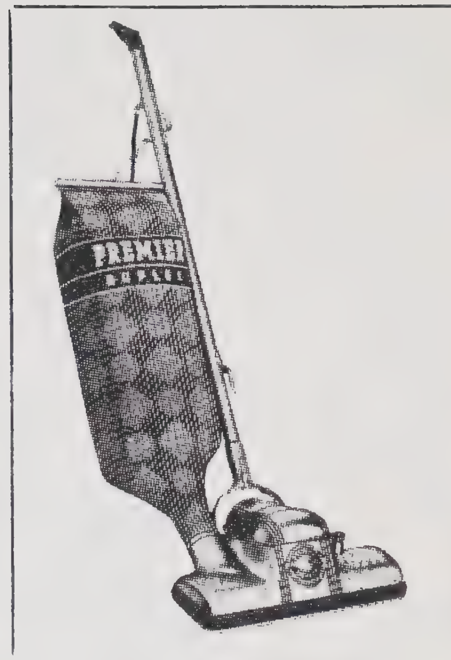
In comparison with the wind plant, the principal advantage of the engine plant is its greater dependability as a source of power, provided it is maintained in good running order. Frequently farmers are able to repair and overhaul their own engines. Where a major overhaul is necessary, for example, "reboring", the engine is sent to recognized repair shops. As a general rule, while mechanical troubles do occur, the plant gives very little trouble, especially during the first few years of operation, and farmers are well satisfied. Where the engine has failed to give satisfaction adjustments have been made, and in some cases new engines have been supplied.

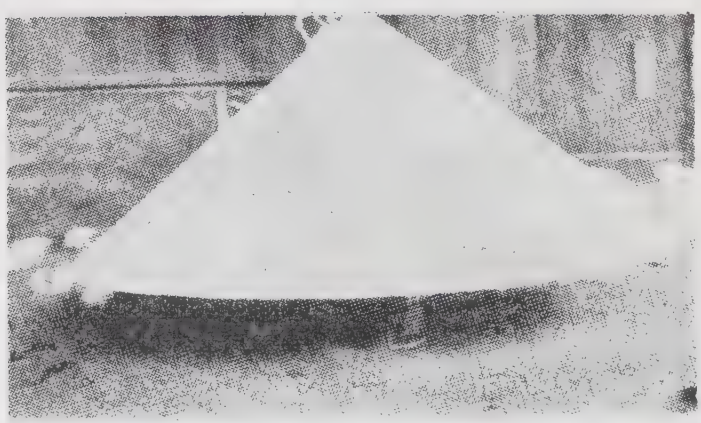
The choice of location for the plant presents some problems. While most plants are installed in the basement of the house, there are various drawbacks to this arrangement, including, fumes, vibration, noise, and interference with the radio. These inconveniences can be materially reduced by installing the engine on a cement block separate from the floor, and by having the exhaust pipe lead directly outside. Nevertheless, it would appear preferable to have the engine in some other building such as a heated garage or milk house. Batteries might be left in the basement in order to have a cool place with an even temperature. The main drawback to this

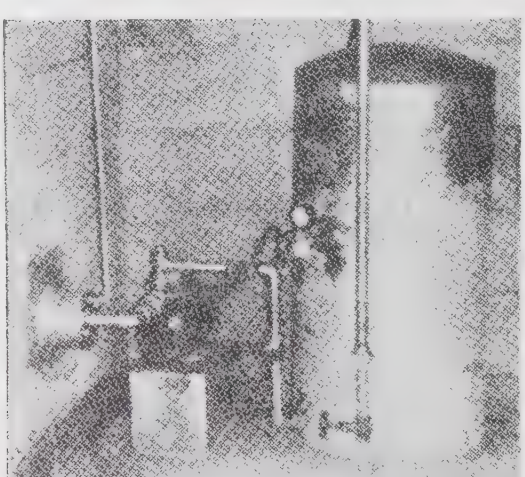


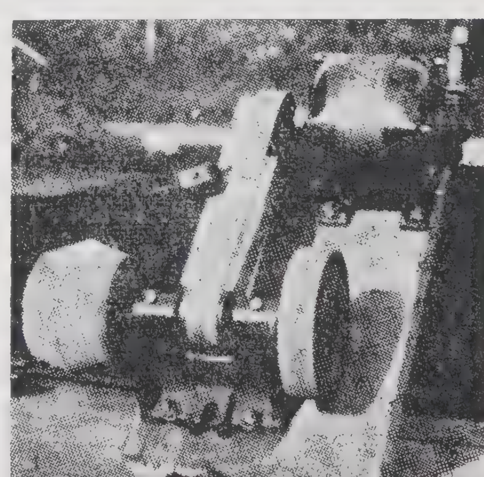
An Engine and Battery Arrangement.











Some Electrical Appliances That are Found on Farms—(1) Washing Machine (2) Vacuum Cleaner (3) Brooder (4) Pressure Pump System (5) Emery Wheel.

arrangement is the loss which will occur over the line between the motor and the batteries.

Although lighting is the main use to which engine plants are put, 90 per cent of the farms surveyed had other appliances (Table 12).

Table 12.—Appliances in Use on Farms with Engine Plants

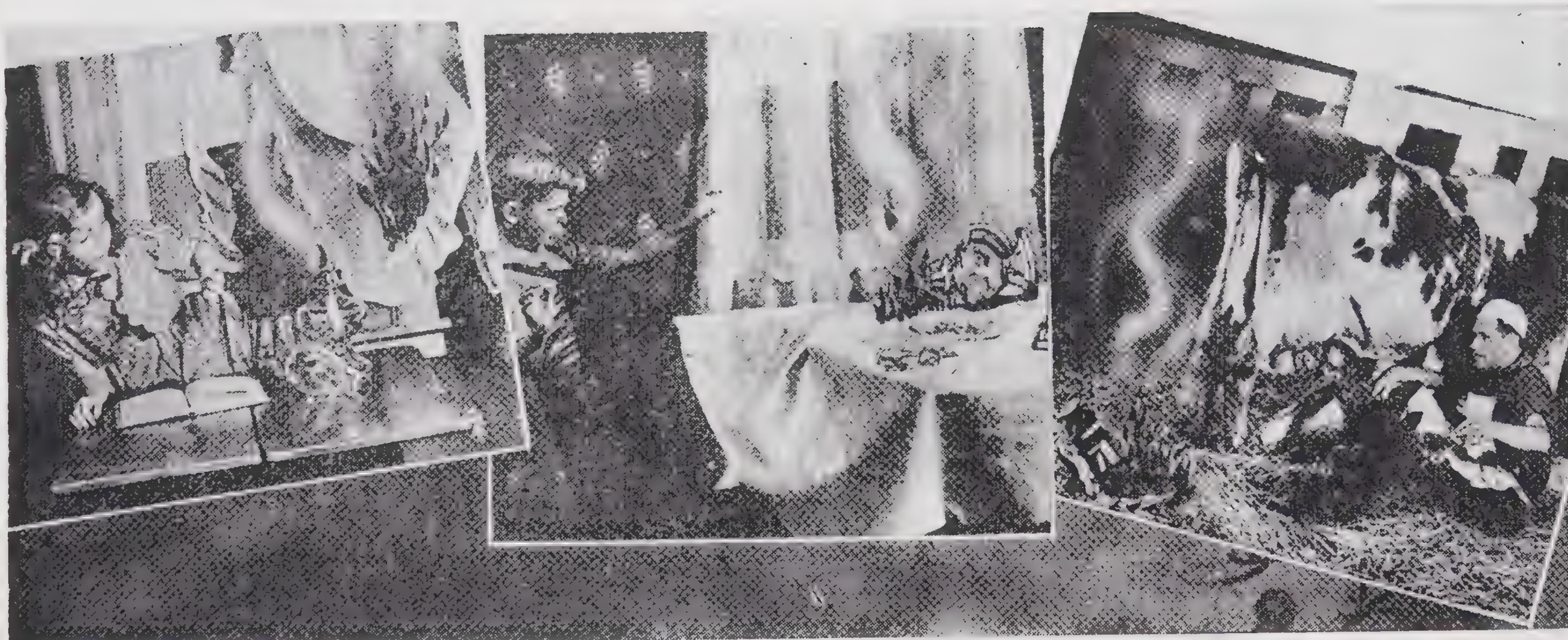
Size of Plant	Lights per Farm	Proportion of Farms with Radio	Proportion of Farms with Washing Machine
Watts	No.	%	%
850	25	36	79
1,000	30	21	64

In addition to the radio and washing machine, 73 other appliances were reported on the 53 farms. These appliances included the iron, sewing machine, vacuum cleaner, automatic pressure pump, emery wheel, fanning mill, churn, electric drill, razor, hot plate, bottle washer, refrigerator, cream separator, and the milking machine (generally run directly off the engine).

Few farmers operate the appliances which require considerable energy such as the iron and milking machine. When these appliances are in use it is customary to operate the engine to prevent too heavy a drain on the batteries. As the batteries get older they will neither take nor hold the same charge as when new; consequently requiring longer and more frequent periods of charging.

There is some difference of opinion among farmers with regard to the merits and demerits of wind and engine plants. It is generally claimed that the wind plant is safer although less reliable as a source of power; and farmers with plants are uniformly of the opinion that either type of plant is to be preferred to the older methods of farm lighting. Apart from the additional uses to which electric power may be put, safety has been a large factor in persuading farmers to install lighting plants. The opinion was frequently expressed that the plant was one of the best investments on the farm.

What has already been said of each plant applies when the two are used in combination. Although the investment in the combination plant is relatively large, an increasing number of farmers appear to believe that this type of plant provides the most reliable source of energy. There are, of course, circumstances which would make it inadvisable to install the combined plant. For example, the wind generator may be of little use to a farmer located in a coulee or thickly wooded



Electric Lighting Decreases the Fire Hazard.

section. Where farmers have both types of plant they have usually been purchased at different times. Farmers with wind plants found themselves without energy during the winter and purchased an auxiliary engine. Other farmers with engine plants wished to save their engine and reduce operating expenses. It appears probable that, in the future, an increasing number of farmers, who are in a position to make the initial investment, will purchase both plants at the same time.

The installation of the auxiliary plant has not resulted in any appreciable increase in appliances (Table 13).

Table 13.—Appliances in Use on Farms with Combination Plants

Size of plant	Various
Number of lights per farm	31
Proportion of farms with radio	63%
Proportion of farms with washing machines	89%

A Large Alberta Farm Using Combination Equipment.

In addition to the radio and washing machine 50 other appliances were reported on the 35 farms. While this represents a somewhat greater use of appliances than when one or other type of plant is used alone, the difference is not sufficiently marked to suggest that farmers with combination plants are making full use of the additional capacity available.

Combination plants may have peculiar advantages in some situations. For example, the farmer with a large dairy herd could install the engine in the barn or milk house and run the milking machine directly from it; while, at the same time,

avoiding the drawbacks of placing the engine in the basement of the house. The wind plant could be placed close to the house, to be used mainly for domestic power.

ENERGY CONSUMED.—As farmers do not keep any detailed record of plant operations, and as farm plants are not metered, any estimate of energy generated and consumed can be only a very rough approximation.

During the survey, all farmers visited were asked to estimate the average number of hours per day their plants were in operation in the winter and in the summer months. In addition, those operating engine plants were asked to estimate the number of gallons of fuel used during the year. This information has been used to arrive at some estimates of the energy generated. In the case of wind plants an estimate of the kwhr generated was obtained from the size of the plant and the estimated hours of operation. To arrive at an estimate of consumption, this figure was reduced by a given percentage, depending on the kind of plant, to make allowances for losses. In the case of engine plants this procedure was supplemented by the use of an estimate of fuel used. Evidence from various sources, including information secured from distributors of engine plants, indicates that a gallon of fuel will generate roughly 4 kwhr. The number of kwhr generated by any plant was then arrived at by multiplying the gallons of fuel consumed by four. When the results from the two methods were compared they were found to be reasonably comparable, however, the procedure used for estimating the energy generated on a time basis does not appear as reliable as the fuel basis.

The estimates obtained are shown in Table 14.

Table 14.—Estimated Energy Consumed on Farms with Individual Farm Plants

Type of Plant	Size of Plant	Consumption Annual	Consumption Monthly
	Watts	Kwhr	Kwhr
Wind plant	600- 850	500	40
Wind plant	1,000-1,250	750	60
Engine plant (fuel basis)	850	375	30
Engine plant (time basis)	850	425	35
Engine plant (fuel basis)	1,000	400	35
Engine plant (time basis)	1,000	450	40
Combination plant (fuel and time basis)	Various	875	70

More detailed information on the maximum amount of energy that can be generated by a wind-driven generator is contained in the Appendix to this report.

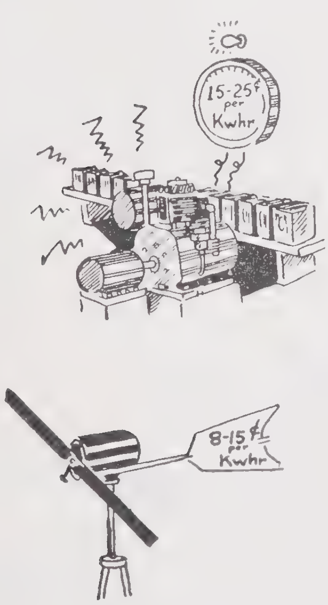
ESTIMATED COST PER KWHR CONSUMED.—Using the estimates of average consumption given in Table 14, and the estimates of costs from Table 10, the average cost per kwhr would be as given in Table 15.

Table 15.—Estimated Cost per Kwhr Consumed.

Type of Plant	Size of Plant	Kwhr Consumed	Cost Annual	Cost Per Kwhr
	Watts		$	¢
Wind plant	600- 850	500	47.75	10
Wind plant	1,000-1,250	750	73.31	10
Engine Plant (fuel basis)	850	375	84.30	23
Engine Plant (time basis)	850	425	84.30	20
Engine Plant (fuel basis)	1,000	400	88.75	22
Engine Plant (time basis)	1,000	450	88.75	20
Combination plant (fuel and time basis)	Various	875	93.37	11

The information available suggests that on the average farm the wind plant provides energy at lower cost per kwhr consumed than the engine plant does. There are two reasons for this. First, total yearly operating expenses are lower for wind plants; and second, the consumption of energy appears to be greater thus reducing the cost per unit of energy.

The costs per kwhr consumed may be roughly estimated to fall within the following ranges; wind plants, 8-15 cents; engine plants, 15-25 cents; combination plants, 10-15 cents.



Costs Per K.W.H.

Comparison with Central Station Power.—The estimates of the cost of providing central station power to farms were based on the construction of 6,900-volt, single phase lines. This type of line would permit the installation of motors up to three horse-power capacity. Motors of this size would provide

for all domestic requirements, and would perform all the more common farm operations to which electrical power can be applied, with the exception of feed grinding with large crushers. Central station power would therefore make possible the installation of more appliances on farms and an expanded use of electrical energy, which would be available at all times without inconvenience or attention. The service obtained from farm plants is somewhat more limited and less reliable, and involves more inconvenience. More time is required in the care and operation of the plant and batteries. Power may not be available if the engine is out of order or the wind fails. Most farmers feel that some appliances which use considerable current cannot be operated successfully by the farm plant.

In Table 16 the estimated costs per kwhr for various types of plant are compared with the cost of central station power at similar levels of consumption.

Table 16.—Comparison of Estimated Costs per Kwhr Consumed.

Type of Plant	Size of Plant	Estimated Kwhr Consumed	Estimated Cost/Kwhr Farm Plant	Farm Lines	Difference in Estimated Cost/Kwhr
	Watts	Kwhr	¢	¢	¢
Wind plant	600- 850	500	10	14	+4
Wind plant	1,000-1,250	750	10	10	0
Engine plant (fuel)	850	375	23	18	—5
Engine plant (time)	850	425	20	15	—5
Engine plant (fuel)	1,000	400	22	15	—7
Engine plant (time)	1,000	450	20	14	—6
Combination plant	Various	875	11	9	—2

As in previous tables the wind plant compares most favourably, in terms of costs, with central station power.

Another method of comparing the service obtained from farm plants with central station power, is to estimate the energy which could be consumed from farm lines for the same cost as is incurred in operating the farm plant. These estimates are given in Table 17.

Table 17.—Estimated Consumption with Farm Plant and Farm Lines at Cost of Operating Farm Plant

Type and Size of Plant		Monthly Cost	Estimated Consumption at Monthly Cost of Operating Farm Plant Farm Plant	Farm Line
	Watts	$	Kwhr	Kwhr
Wind Plant	600- 850	3.98	40	None
Wind Plant	1,000-1,250	6.11	60	70
Engine Plant	850	7.02	35	130
Engine Plant	1,000	7.39	40	150
Combination Plant		7.78	70	170

As already mentioned farmers are generally well satisfied with their plants. But farmers who have experienced the advantages of electrification, through the farm plant, are most anxious to be served with central station power. They realize that their plants are providing them with a welcome, although limited service. If central station power could be made available to them at comparable cost, they would readily change over. Even if costs were somewhat higher many would be prepared to take power off the line.

The advantages of farm line power, in terms of service and convenience, cannot be doubted. But many farmers could greatly increase and improve the service they are now getting from their plants. The data presented in this report are averages, and there are frequently wide differences in the performance of plants of the same type, make, and size on different farms. In many cases the wrong type of plant has been installed. For example, the farmer whose buildings are in a sheltered location has purchased a wind plant, when he could have had much better service from an engine plant. In other cases, the plant has been installed without regard to the recommendations of the manufacturer. For example, much of the inconvenience resulting from noise and fumes of engine plants is the result of failure to install the plant properly; and the problem of insufficient wind to provide continuous service from wind plants is frequently the result of a poor choice of location or a tower which is not high enough to make full use of the wind available. Again, many farmers could make much

In Some Circumstances the Wind Plant Will Not Operate Satsifactorily

fuller use of the equipment they have, at little additional cost. There has been a disposition to think of the farm plant as a "lighting" plant; but, while the advantages of electric light in the home are substantial, the farm plant has many other useful services, both domestic and farm, which it is capable of performing.

Location and Installation of Plant Should be Carefully Planned.

These considerations all point to the importance of giving careful thought to, and securing the best possible advice on the type and size of plant suited to the farm situation and requirements, the manner of installing the plant, and the uses to which the plant can be advantageously put.

SUMMARY.—1. Wind plants are peculiarly subject to the hazards of nature, and the farm may be without energy during extended periods of calm. On the other hand the operating costs of wind plants are relatively low; and they are safe and convenient to operate.

2. Engine plants are comparatively costly to operate, and require more attention than the wind plant. There is more danger of fire with the engine plant, and fumes or noise may constitute a nuisance unless the plant is carefully installed. On the other hand the engine plant provides a somewhat more reliable source of power, and some appliances can be run directly off the engine.

3. Many farmers prefer the combination plant. This arrangement provides a dependable source of power, at costs intermediate between those of the wind and engine plants.

4. It is apparent that fuller and more satisfactory use of plants would result from greater care in their installation, and from the use of additional appliances on many farms.

5. Central station power is preferable in terms of service and convenience, and, over large areas of the Province central station power could be provided at comparable or lower cost per unit of energy consumed. However, there are other areas in which after considering all the advantages and disadvantages, including costs, the decision would have to be in favour of the individual plant.

V. THE SIX-VOLT WIND PLANT

The provision of central station power, and the farm plant of a size sufficiently large to provide power on the average farm, both involve a substantial investment in plant, wiring of buildings, and appliances. In many areas of Alberta conditions are not yet suitable for distribution of central station power to farms; and the investment involved in a large plant would prove beyond the capacity of most farmers. In other cases, the capital required for the large farm plant would be better employed in other forms of farm improvement which would contribute more largely to production and income. The small six-volt wind plant may have a place in areas of this kind.

A Six-Volt Wind Plant

During the survey records were obtained for 12 6-volt plants, ranging in size up to 600 watts. The data for these plants are summarized in the following table (Table 18).

The average investment per farm for plant, wiring and appliances was about $100; total operating costs were less than $1.00 per month per farm; and cash expenses of operation were estimated at less than 50 cents a year. Against this cheapness must be set the very limited service; and it is obvious that this type of plant could not be recommended where the installation of a larger plant is practical. However, where this is not the case the small plant will help to light the home, permit the use of an electric radio or enable the

Table 18.—Wind-Driven Plants: 6-volt (12 plants)

Size of wind plant		Up to 600 watts, 6-volt
Batteries		Mostly 3, 2-volt
Life of wind plant	Yrs.	10
Life of batteries	Yrs.	8
Cost of wind plant	$	35.00
Cost of batteries	$	33.00
Total cost of plant	$	68.00
Wind plant:		
Depreciation, 10 years[1]	$	3.50
Interest, at 3 per cent	$	1.05
Repairs	$	0.16
Oil[2]	$	0.03
Batteries:		
Depreciation, 8 years	$	4.12
Interest, at 3 per cent	$	0.99
Upkeep	$	0.08
Insurance	$	0.17
Total yearly cost	$	10.10
Cost of wiring buildings	$	25.00
Number of lights	No.	6

From the 12 records, 5 reported operating a radio an average of 3 hours a day.

[1]In calculating depreciation for the larger wind plants, an average life of 20 years was assumed.

[2]The expenditure for oil on all wind plants includes oil for the generator and varnish for the blade.

farmer to charge his own radio, as well as car or truck batteries, at costs little, if any, greater than the cost of fuel for lighting farm buildings[1].

The plants found during the survey were all purchased and of standard type. However, small 6-volt plants using automobile generators and batteries could be constructed and installed on the farm. It is not suggested that all farmers would be able to undertake construction themselves; but it seems

[1]The Manitoba Electrification Enquiry Commission estimated the average cost of fuel per farm for lighting at $9.07 per year. Op. cit., Table 24, p. 138.

possible that, in areas in which a demand for this type of plant might exist, the plant could be assembled and the tower built and installed by local people[1].

[1]A discussion of the construction and installation of farm plants would go beyond the scope of this report. Information and advice on the construction, care and operation of six-volt wind plants can be found in the following:

"Six Volt Wind Electric Plants," Department of Agricultural Engineering, University of Saskatchewan. Mimeographed circular, 1941.

"Homemade Six-Volt Wind-Electric Plants", H. F. McColly and Foster Buck. Extension Service, North Dakota Agricultural College, Fargo, North Dakota. Special Circular. January 1939.

VI. CONCLUSIONS

TWO MAIN QUESTIONS arise in connection with the farm plant.

(1) **How does the farm plant perform as a source of energy?**

The related questions are: What is the experience of farmers who have installed farm plants? Are farmers satisfied with the service they get for the costs incurred? What trends are evident? What sort of service do the plants provide? Which type of plant is to be preferred?

(2) **How does the farm plant compare with the farm line as a source of energy?**

The related questions are: is one source of power always preferable to another? What conditions are relatively favourable to central station power? What conditions are relatively favourable to the farm plant?

The information derived from the survey of farm plants is presented in this report, and is summarized at the end of each section. Throughout the report comparisons are made between the farm plants and farm line power.

The information should help to provide answers to the questions mentioned above.

The Farm Plant as a Source of Energy

Farmers who have installed farm electric plants are generally well-satisfied with the performance of the plants, with the service they provide, and with the costs of operation. However, not more than 6-7 per cent of Alberta farmers have plants. There are three main reasons for this.

First, the electrification of the farm through the individual plant requires a substantial initial investment in plant and batteries, wiring of buildings, and appliances. For an appropriate size of plant, say 1,000 watts, with adequate wiring and appliances to make full use of it, the initial investment would amount to between $800 and $1,000. During the thirties, when farm incomes were generally low, few farmers were in a position to make an investment of this amount. Second, since 1940 there has been a considerable increase in the number of plants, particularly wind plants, on farms, but the process of electrification has been impeded by scarcity of plants and appliances. Were farm income maintained at their present levels, electrification of farms would proceed rapidly when plants and equipment become available in

larger quantities. Third, not all farmers are informed on the type of service which can be provided by the farm plant.

Where difficulties have been encountered in the operation of farm plants, these can frequently be traced to faulty installation or improper care of the plant or batteries; and it is apparent that many farmers are making considerably less than full use of the plants they have. To secure maximum service from the farm plant careful consideration must be given to the choice of the size of plant, and to the location and manner of installation. The survey provided ample evidence that insufficient attention is given to these important considerations. Many farmers are content to use their plants largely for lighting or for lighting and one or two domestic appliances. The fact that some farmers are able to secure sufficient energy for other domestic and farm equipment is conclusive evidence that the plants are capable of handling the heavier load. The failure on the part of many farmers to install additional appliances suggests a tendency to overlook the fact that, once the heavy overhead costs involved in installing the plant have been incurred, the additional costs of added service are small.

There is a noticeable tendency toward larger plants. Farmers who have already experienced the advantages of electrification are anxious to extend the service they are already getting. While, as already pointed out, many farmers could get considerably more use from the plants they have, there is a limit to the load which any plant will carry. For this reason a trend toward larger plants is to be expected. This development is associated with the increasing use of the combination plant. However, the combination plant has advantages other than the increased capacity it provides.

The Engine Plant Rests When Possible.

Where both wind and engine plants have been installed, the customary procedure is to use the wind plant as the main source of energy, and the engine plant as auxiliary. This permits the farmer to take advantage of the low operating costs of the wind plant, while overcoming its principal disadvantage, namely, the loss of power at time when the wind velocity is insufficient to charge the batteries. Consequently, although the initial investment is relatively high, consumption with the combination plant is generally greater than with the

wind or engine plant alone; and costs per kwhr consumed, although slightly higher than for the wind plant, are considerably lower than for the engine plant.

The choice of type of plant will be influenced by the capacity of the farmer to make the investment required; but other considerations are also important. Conditions in certain areas are no doubt more favourable to the wind plant than in other districts or locations; and some farmers may be so situated that they would get little service from a wind plant. In such situations even the combination plant could not be recommended. In other locations the wind plant with a heavy set of batteries might be capable of giving uninterrupted service. Where the power requirements are large the combination plant provides added capacity and assurance of continuous service. On some large farms the small diesel plant may meet the requirements most economically.

There are in the Province of Alberta many small farms, and relatively undeveloped farms in newer areas. In these cases, the investment required to install a large electric plant may be either beyond the capacity of the farmer, or clearly undesirable under the immediate conditions. In many cases, the capital required could more advantageously be used to secure other equipment for the development of the farm. Under these conditions the small 6-volt wind plant may meet an immediate need. Installation and operating costs for this type of plant are small; but the service is limited to a few lights in the house, and the charging of radio, car, or truck batteries.

Comparison of the Farm Plant and the Farm Line.

Progress in the construction of farm distribution lines is to be expected; but two things are obvious. First, even with assistance being given to the provision of central station power to farms, extension of farm lines will take place gradually and it will be many years before the suitable areas are covered. In the meantime many farmers are anxious to electrify their farms, and have accumulated savings which they are prepared to apply to this purpose. Second, there are large areas of the Province in which, after considering all the advantages and disadvantages, including costs, of the alternative sources of power, the decision would have to be in favour of the individual farm plant. So far as can be seen there is no immediate prospect of taking central station power to farms in these areas.

Farmers in areas which may be considered suitable for farm distribution lines, but which are unlikely to be served with central station power for a number of years, might well consider the installation of a farm plant. It seems likely that,

if conditions warrant the extension of farm lines, there will be a ready market for used plants; and if the farmer has the opportunity of taking central station power he will be able to dispose of his plant and appliances at prices close to cost less depreciation. In those areas in which conditions are not favourable to the distribution of central station power, that is, in areas of low density of farms, farm electrification will depend on the individual farm plant.

Farm line power offers substantial advantages in terms of service and convenience. The service provided cannot be judged wholly without consideration to cost. It would be possible to install a farm plant which would be capable of providing sufficient energy to perform all the operations to which electrical power could be applied on the farm. However, comparing the type of farm line which appears appropriate to Alberta conditions with the type of plant commonly found on farms, the former would provide the more adequate service. Perhaps the advantages of farm line power are most obvious in regard to convenience. Once the farm is connected to the line, power can be had merely by turning the switch. With the individual plant the farmer must give time and attention to his plant and batteries; and may require some skill to get the best results.

There are however only certain conditions under which the cost of central station power could be comparable to the cost of energy provided by the power plant. The important factors are the number of connections per mile of line and the consumption per farm.

The data presented in the report suggests that average total operating costs range from $4 to $7 per month for wind plants; from $6 to $8 a month for engine plants; and from $7 to $9 a month for combination plants. On the basis of rough estimates of the energy consumed these monthly costs reduce to about 10 cents per kwhr for wind plants; 11 cents per kwhr for combination plants; and over 20 cents per kwhr for engine plants. In the case of the wind and combination plants these costs are substantially lower than the rates charged to domestic users for limited service in many villages served by diesel plants. These rates are frequently as high as the cost of energy provided by the gasoline engine plant.

In a previous report on farm electrification it was estimated that, under certain conditions, central station power could be made available to farms at a cost of $5.70 a month, with a monthly consumption of 50 kwhr, or at 11.4 cents per kwhr. These costs are comparable to the average costs of energy provided by wind plants.

The estimated cost of line power was based on serving groups of farms rather than individual farms, and on speci-

fied groups of farms rather than individual farms, and on specified conditions regarding the number of connections per mile of line including service tap-off. More specifically the conditions included:

(a) The serving of farms within a distance of 12 miles from existing transmission lines, and from a sub-station on the transmission line.

(b) A sufficient number of farm connections to serve 100 farms off a sub-station, with 74 miles of road line and tap off, that is, 1.35 connections per mile.

In areas of greater density of farms these conditions could readily be met; and, where the number of connections exceeded 1.35 per mile, the cost per farm would be below the amount estimated. On the other hand, in any area in which fewer than 1.35 connections per mile could be secured, the cost per kwhr at a monthly consumption of 50 kwhr would be greater than the amount estimated. Considering only the costs which enter into the accounting process, the wind plant might be recommended for the latter type of area. However, service, convenience, and reliability should also be taken into consideration.

The other important factor affecting the relative advantage of energy from the line or from the farm plant is the probable consumption per farm. The proposed 6,900 volt farm distribution line would permit a larger consumption per farm than it seems reasonable to expect of the common sizes of farm plant, under average farm conditions. If, with farm distribution lines, consumption per farm could be increased to 100 kwhr a month, the estimated cost would be $6.52 a month, and the cost per kwhr would be reduced to 6.5 cents. To provide for this consumption, under average farm conditions, larger sizes of plant would be required than those now commonly in use. The installation of the larger plant would require a larger investment, which would increase the overhead and operating costs. It seems probable, therefore, that at higher levels of consumption per farm the balance of advantage would move in favour of central station power.

Conditions are relatively favourable to central station power in areas of greater density of farms, and especially in those areas in which the type of farming would result in a large consumption of energy per farm. Conditions are relatively favourable to the individual farm plant in areas in which the density of farms is low, and especially in areas where farm consumption might be small.

APPENDIX A

Tables I to VI are based on information obtained from the survey of farm plants in Alberta, and show in detail the average operating costs for various types and sizes of 32-volt plants.

Table I.—Operating Costs of Wind Plants

Description		Group 1 (19 records)	Group 2 (16 records)
Size of wind plant	Watts	600-850	1,000-1,250
Batteries		16, 2-volt	16, 2-volt
Life of wind plant	Years	20	20
Life of batteries	Years	8	8
Cost of wind plant	$	218	330
Cost of batteries	$	178	251
TOTAL COST OF PLANT	$	396	581
Wind Plant:			
Depreciation, 20 years	$	10.90	16.50
Interest, at 3 per cent	$	6.54	9.90
Repairs	$	1.41	5.94
Oil	$	.30	.58
Batteries:			
Depreciation, 8 years	$	22.25	31.38
Interest, at 3 per cent	$	5.34	7.53
Upkeep	$	.12	.22
Insurance	$	.89	1.26
TOTAL YEARLY COSTS	$	47.75	73.31
Cost of wiring building	$	109	127

Table II.—Summary of Lighting and Appliances: Wind Plants

Description		Group 1 (19 records)	Group 2 (16 records)
Number of lights in house		12	16
Number of lights in barn		3	5
Number of lights in chicken house		1	1
Number of lights in other		3	2
Total		19	24
Percentage operating radio		42	44
Percentage operating washer		63	94
Average time operating radio per day	Hrs.	3.5	3.9
Average time operating washer per week	Hrs.	2.5	2.3

Group 1 reported 18 other appliances.
Group 2 reported 22 other appliances.

Table III.—Operating Costs of Engine Plants

Description		Group 1 (13 records)	Group 2 (39 records)	Group 3 (14 records)	Group 4 (9 records)
Size of plant	Watts	500-800	850	1000	1,250-1,500
Condition when purchased		New and second-hand	New and second-hand	New and second-hand	New and second-hand
Batteries		16, 2-volt	16, 2-volt	16, 2-volt	16, 2-volt
Life of plant[1]	Years	20 and 15	20 and 15	20 and 15	20 and 15
Life of batteries	Years	8	8	8	8
Cost of plant	$	218	213	256	201
Cost of batteries	$	173	178	189	176
TOTAL COST OF PLANT	$	391	391	445	377
Average number of years plant on farms		8	10	6	8
Plant:					
Depreciation 15 and 20 years	$	11.65	12.70	14.68	12.64
Interest, at 3 per cent	$	6.54	6.39	7.68	6.03
Repairs	$	10.91	5.69	3.18	3.49
Insurance	$	1.09	1.07	1.28	1.01
Fuel	$	21.85	22.71	25.26	24.37
Oil	$	3.53	6.94	5.94	3.82
Batteries:					
Depreciation 8 yrs.	$	21.63	22.25	23.62	22.00
Interest, at 3 per cent	$	5.19	5.34	5.67	5.28
Upkeep	$	.21	.32	.49	.22
Insurance	$	.87	.89	.95	.88
TOTAL YEARLY COSTS	$	83.47	84.30	88.75	79.74
Average cost of wiring	$	109	142	166	134

1 20 Years for new plants; 15 years for reconditioned plants.

Table IV.—Summary of Lighting and Appliances; Engine Plants

Description		Group 1 (13 records)	Group 2 (39 records)	Group 3 (14 records)	Group 4 (9 records)
Number of lights in house		16	16	18	14
Number of lights in barn		4	3	6	5
Number of lights in chicken-house		5	2	2	1
Number of other lights		3	4	4	4
TOTAL		28	25	30	24
Percentage operating radio		42	36	21	33
Percentage operating washer		83	79	64	78
Average time radio operating per day	Hrs.	3.0	3.5	2.3	4.7
Average time washer operating per week	Hrs.	3.3	3.4	3.4	2.3

Group 1 reported 10 other appliances.
Group 2 reported 60 other appliances.
Group 3 reported 13 other appliances.
Group 4 reported 6 other appliances.

Table V.—Operating Costs of Combination Plants

Description		Group 1 (15 records)	Group 2 (20 records)	All Combination Plants (35 records)
Size of engine plant		Varying	Varying	Varying
Size of wind plant	Watts	650-850	1,000-1,250	Varying
Batteries		16, 2-volt	16, 2-volt	16, 2-volt
Life of engine plant	Years	20	20	20
Life of wind plant	Years	20	20	20
Life of batteries	Years	8	8	8
Cost of engine plant	$	184	213	200
Cost of wind plant	$	239	291	269
Cost of batteries	$	198	237	220
TOTAL COST OF PLANT	$	621	741	689
Plants:				
Depreciation, 20 years	$	21.15	25.20	23.45
Interest, at 3 per cent	$	12.69	15.12	14.07
Repairs	$	7.92	7.13	7.46
Insurance	$	.92	1.07	1.00
Fuel	$	5.81	9.94	8.17
Oil	$	2.51	4.41	3.59
Batteries:				
Depreciation, 8 years	$	24.75	29.63	27.50
Interest, at 3 per cent	$	5.94	7.11	6.60
Upkeep	$	.20	.60	.43
Insurance	$	.99	1.19	1.10
TOTAL YEARLY COST	$	82.88	101.40	93.37
Average cost of wiring	$	138	171	157

Table VI.—Summary of Lighting and Appliances; Combination Plants

Description		Group 1 (15 records)	Group 2 (20 records)	All Combination Plants (35 records)
Number of lights in house		19	19	19
Number of lights in barn		6	7	6
Number of lights in chicken house		2	1	1
Number of lights in other		2	7	5
TOTAL		29	34	31
Percentage operating radio		60	65	63
Percentage operating washer		80	95	89
Average time radio operating per day	Hrs.	5.8	3.8	4.6
Average time washer operating per week	Hrs.	3.0	3.3	3.2
Group 1 reported 20 other appliances.				
Group 2 reported 29 other appliances.				
Group 3 reported 49 other appliances.				

APPENDIX B

Extract from a report of the Department of Agricultural Engineering, University of Saskatchewan, entitled "Wind Electric Research Report. Summary of 12 Months' Data, December 1st, 1939 to November 30th, 1940." This material indicates possible production and consumption of energy from a 1,000 watt 32-volt Wincharger.

Table II is a monthly summary of the production and consumption from the 1,000 Watt 32-Volt Win-charger, December 1939 to November 1940 (inclusive)

TABLE II

Month	No. days	No. days no Ch'g	No. days no Disch.	Kwhr Prod. from Gener.	Kwhr used from Bat.	Bat. Eff.	Kwhr Prod. 4 p.m. to 8 a.m.	Kwhr Prod. 8 a.m. to 4 p.m.	% Prod. at night	Ave. Kwhr Prod. per day	Ave. Kwhr used per day
December	31	5	2	82.50	76.80	....	55.15	27.35	66.8	2.66	2.45
January	31	5	13	76.01	43.06	....	47.04	28.97	59.9	2.45	1.39
February	29	2	2	98.35	76.00	....	55.59	42.76	56.5	3.39	2.45
March	31	6	0	96.18	78.90	....	58.94	37.24	61.3	3.31	2.54
April	30	1	0	120.10	119.80	....	66.07	54.03	55.1	4.00	3.99
May	31	0	2	110.30	96.75	....	61.18	49.12	55.5	3.56	3.12
June	30	0	6	103.60	87.49	....	57.83	45.77	55.7	3.45	2.92
July	31	1	6	69.62	55.40	....	37.09	32.53	53.2	2.25	1.79
August	31	0	0	97.10	82.40	....	52.08	45.02	53.6	3.13	2.50
September	30	1	0	51.44	50.74	....	29.19	22.25	56.7	1.72	1.59
October*	31	0	3	101.30	108.15	....	57.41	43.89	56.6	3.27	3.49
November	30	3	5	98.51	80.78	....	51.30	47.21	52.1	3.28	2.69
12 months	366	24	39	1105.01	956.27	86.54%	628.87	476.14	56.91%	3.02	2.62

*The battery was fully charged (1225) at the beginning of October 1940 and fully discharged (1170) at the end of October 1940. Thus more current was consumed than was produced during this month.

Also it will be observed that in January 1940 there were 13 days when the batteries were too low to produce usable current. This, however, was during a period of almost unprecedented calm as may be seen from the following wind table.

While there were 39 days in the year that the battery did not have sufficient energy to allow any consumption, yet under actual farm conditions the number would not be so great. The load of motors and appliances under farm conditions would be reduced or cut off entirely during long calm spells to enable the battery energy to be conserved for lights only. During extreme calms the light load would also be reduced somewhat. However under our test conditions we allowed the regular discharge rate to continue until the battery was run down and did not reduce the load at all.

Table III compares the production with the average wind velocity and the total wind movement for each month

TABLE III

Month	% days no Chg'g	% days no Disch.	Ave. Wind Vel.	Av. Wind Velocity for last 6 years	Total Miles Wind Movement	Av. miles Wind Mov't for last 6 years	Kwhr Prod.	Kwhr Prod. per 100 miles Wind Mov't	Index of Kwhr Produced per month April=100
December	19.2	6.4	9.9	10.9	7,341	8,657	82.5	1.124	69
January	19.2	4.19	8.6	10.1	6,390	7,077	76.01	1.189	63
February	6.9	6.9	9.5	9.4	6,600	6,469	98.35	1.490	82
March	19.4	0.0	9.6	11.8	7,105	9,175	96.18	1.353	80
April	3.3	0.0	12.3	13.0	8,853	9,324	120.10	1.357	100
May	0.0	6.4	11.6	13.8	8,674	10,245	110.30	1.272	92
June	0.0	20.0	11.0	11.6	7,929	8,348	103.60	1.306	86
July	3.2	19.3	9.5	10.9	7,054	8,138	69.62	.987	58
August	0.0	0.0	10.8	11.2	8,089	8,327	97.10	1.200	81
September	3.3	0.0	9.1	10.6	6,572	7,607	51.44	.783	43
October	0.0	9.7	10.9	12.1	8,080	9,033	101.30	1.254	84
November	10.0	16.6	9.8	11.2	7,070	8,023	98.51	1.393	82
Average	7.04	10.6	10.2	11.4	7,480	8,369	98.09	1.113	----

It will be seen from the above table that the kwhr produced per 100 miles wind movement are very low in July and September. From examination of the wind record it was found that average velocity for these two months was made up of uniformly low velocity winds instead of winds of more widely varying velocities as was the case during the other ten months. This fact accounts for the lower production during July and September.

Also it will be seen that the average wind movement for the entire twelve months was below the six year average with the single exception of February. Thus it could be assumed that if an average monthly wind movement of 7,480 miles gave an average monthly production of 98.09 kwhr, then a probable production of 110 k.w. hrs. average per month could be expected from this 1,000 watt, 32-volt plant. This would give an average yearly production of 1,320 kwhr at Saskatoon.